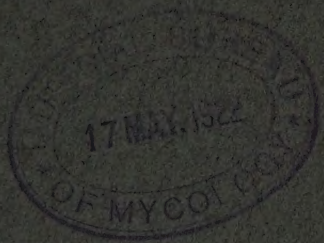
G-257

TRANSPORTATION ROTS OF STONE FRUITS AS INFLUENCED BY ORCHARD SPRAYING

BY

CHARLES BROOKS AND D. F. FISHER

Reprinted from JOURNAL OF AGRICULTURAL RESEARCH
Vol. XXII, No. 9 : : : Washington, D. C., November 26, 1921



PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE, WITH THE COOPERATION OF THE ASSOCIATION OF LAND-GRANT COLLEGES

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1921

TRANSPORTATION ROTS OF STONE FRUITS AS INFLUENCED BY ORCHARD SPRAYING

By CHARLES BROOKS and D. F. FISHER, *Pathologists, Fruit Disease Investigations, Bureau of Plant Industry, United States Department of Agriculture*

The present paper reports the pathological results of five years' shipping and storage experiments with green prunes and sweet cherries and is an attempt to demonstrate certain underlying facts that help to place the responsibility for transportation and market losses in perishable fruit shipments. Sprayed fruit and dusted fruit have been compared with untreated fruit from the same orchards under various transportation and storage conditions.

Spoilage of fruit has been almost entirely due to Monilia or brown rot [*Sclerotinia cinerea* (Bon.) Wor.], blue mold rot [*Penicillium expansum* (Lk.) Thom], and black mold rot [*Rhizopus nigricans* Ehr.]. Monilia attacks the fruit both in the orchard and on the market, but Penicillium and Rhizopus are able to develop only on the harvested fruit.

SPRAYED AND UNSPRAYED SWEET CHERRIES IN TRANSIT AND IN STORAGE

The shipping experiments on cherries were made from the orchard of L. T. Reynolds of Salem, Oreg. The varieties used were Napoleon (Royal Ann), Black Republican, and Lambert. Various standard spray materials were used on the different orchard plots, including 2–4–50 Bordeaux plus 2 pounds of rosin fish-oil soap, 8–8–50 self-boiled lime-sulphur plus 2 pounds of rosin fish-oil soap, and commercial lime sulphur diluted 1 to 50. In the 1919 experiments a neutral Bordeaux (4 pounds copper sulphate in 100 gallons water neutralized with lime) was substituted for the 2–4–50 Bordeaux, a casein spreader [1] was added to the lime sulphur solution, and one plot was treated with 85–0–15 [2] sulphur dust.

In 1915 sprayings were made May 7 and 8 and June 1; in 1916, Aprll 1, April 21, May 12, and June 15; in 1917, April 25, May 14, May 31, and June 22; in 1918, April 15, May 2, May 17, and June 18; and in 1919, June 7 and June 16. The earlier applications (before May 10) were for the control of blossom infection and probably had little effect upon the occurrence of rot on the ripe fruit.

In 1915 and 1916 there was practically no foliage injury from any of the spray materials used, but in each of the following three years very definite injury occurred on particular plots. In 1917 and 1918 lime sulphur caused heavy defoliation, and in 1919 Bordeaux produced considerable foliage injury. All of the spray materials, with the possible exception of neutral Bordeaux, reduced the size of the cherries. In most years this was scarcely perceptible, but in 1917 the dwarfing effect was sufficient to cause considerable loss.

The cherries of the Willamette Valley are often seriously damaged with brown rot, yet during the five years' work at Salem there was not a season in which the experimental orchard had as much as 1 per cent of rot at picking time on either the sprayed or unsprayed fruit.

Shipping experiments were made each year to determine the effect of the orchard treatment upon the carrying quality of the cherries. One

[1] FISHER, D. F. CONTROL OF APPLE POWDERY MILDEW. U. S. Dept. Agr. Farmers' Bul. 1120, 14 p., 8 fig. 1920.

[2] The formula is given in sulphur, lime, arsenic sequence: 85 parts sulphur, no lime, and 15 parts arsenate of lead.

Journal of Agricultural Research,
Washington, D. C.
aaq

Vol. XXII, No. 9
Nov. 26, 1921
Key No. G-257

74381—22

or more 10-pound boxes of sound cherries from each plot were included in each shipping test, thus giving a minimum of approximately 1,000 cherries upon which to base any item of a count.

All the shipments were made by express, a part without ice and a part in pony refrigerators. The refrigerators held sixteen 10-pound boxes of fruit. They were well insulated and when properly iced maintained a temperature of 10° to 13° C. (50° to 55.4° F.), usually bringing the warm fruit down to this temperature in less than two days.

The results of the various shipping experiments are given in Tables I to VI and a summary in figure 2.

TABLE I.—*Effect of spraying Napoleon* [1] *and Black Republican* [2] *cherries, Salem, Oreg., 1915*

Variety.	Orchard treatment.	Percentage of Monilia at picking time.	Condition of fruit after shipment and storage.			
			Percentage of rot.			Percentage of sound fruit.
			Monilia.	Penicillium.	Rhizopus.	
Napoleon	Bordeaux	0.2	10.6	3.8	0	88.9
	Self-boiled lime sulphur	.2	11.1	37.9	12.9	38.1
	Untreated	.7	52.1	7.3	20.2	20.4
Black Republican.	Bordeaux	.03	6.5	15.4	4.8	73.3
	Self-boiled lime sulphur	.07	2.0	10.1	1.6	86.3
	Commercial lime sulphur.	.05	7.8	12.1	.03	80.1
	Untreated	.03	17.3	3.7	1.3	77.7

[1] The Napoleon cherries were picked June 17, stored at 5° C. (41° F.) on June 18, removed and shipped by express without refrigeration June 27, received at Wenatchee, Wash., June 29, still practically free from rot, and held in a warm laboratory till July 2, when notes were taken.

[2] The Black Republican cherries were picked June 24, stored at 5° C. (41° F.) June 25, removed and shipped by express without refrigeration June 27, received at Wenatchee, Wash., June 29, still practically free from rot, and held in a warm laboratory till July 6, when notes were taken.

TABLE II.—*Effect of spraying Napoleon* [1] *and Black Republican* [2] *cherries, Salem, Oreg., 1916*

Variety.	Orchard treatment.	Percentage of rot after shipment and storage.			Percentage of sound fruit.
		Monilia.	Penicillium.	Rhizopus.	
Napoleon	Bordeaux	12.6	7.4	0	80.0
	Self-boiled lime-sulphur	40.5	12.0	3.7	43.8
	Commercial lime-sulphur	21.5	16.2	2.4	59.9
	Commercial lime-sulphur (last spraying omitted).	64.5	4.1	20.0	11.4
	Untreated	80.8	16.7	0	2.5
Black Republican.	Bordeaux	19.6	4.0	1.1	75.3
	Self-boiled lime-sulphur	24.7	.7	.3	74.3
	Commercial lime-sulphur	14.2	14.2	.6	71.0
	Commercial lime-sulphur (last spraying omitted).	36.9	.8	.2	62.1
	Untreated	35.0	.1	0	64.9

[1] The Napoleon cherries were picked July 3, stored at 5° C. (41° F.) July 4, removed and shipped by express without refrigeration July 6, received at Wenatchee, Wash., July 8, and held in a warm laboratory till July 20, when notes were taken.

[2] The Black Republican cherries were picked July 6 to 10, stored at a temperature of 5° C. (41° F.) till July 14, shipped by express without refrigeration to Wenatchee, Wash., received July 16, and held in a warm laboratory till July 21, when notes were taken.

TABLE III.—*Effect of spraying Napoleon* [1] *and Lambert* [2] *cherries, 1916*

Orchard treatment.	Percentage of rot after shipment and storage.					
	On Napoleon.				On Lambert.	
	July 12.		July 13.		July 22.	
	Monilia.	Other rots.	Monilia.	Other rots.	Monilia.	Other rots.
Bordeaux	2.2	0.2	6.0	0.8	5.6	4.2
Self-boiled lime-sulphur	11.0	0	23.8	1.2	5.7	1.6
Commercial lime-sulphur	4.0	0	7.5	.8	7.0	11.6
Commercial lime-sulphur (last spraying omitted)	1.5	0	9.5	1.8	3.7	12.0
Untreated	14.8	.1	37.7	1.6	21.0	3.6

[1] The Napoleon cherries were picked July 5 and shipped in pony refrigerators the same day, received in Washington, D. C., July 12, with ice pans empty and fruit warm, and held without cooling till July 13.
[2] The Lambert cherries were picked July 14 and shipped in pony refrigerators the same day, received in Washington, D. C., July 21, and notes taken on July 22.

TABLE IV.—*Effect of spraying Napoleon,*[1] *Black Republican,*[2] *and Lambert* [3] *cherries, 1917*

Orchard treatment.	Percentage of rot after shipment and storage.						Percentage of rot after shipment on Lambert.		
	On Napoleon.			On Black Republican.					
	Monilia.	Penicillium.	Rhizopus.	Monilia.	Penicillium.	Rhizopus.	Monilia.	Penicillium.	Rhizopus.
Bordeaux	0	0.2	0	0.2	11.8	2.4	0.1	0.5	2.8
Self-boiled lime-sulphur	.1	0	0	0	2.0	9.3	0	0	2.2
As above, but last application omitted	.3	.3	0	0	.4	1.1	.....	.....	.....
Commercial lime-sulphur	0	0	1.3	.1	.3	.1	.6	.3	4.0
Untreated	.3	.1	.9	2.7	.1	1.4	5.0	.1	11.9

[1] The Napoleon cherries were picked July 7 and shipped in pony refrigerators the same day, received in Wenatchee, Wash., July 12, and held in a warm room till July 14, when notes were taken.
[2] The Black Republican cherries were picked July 15, packed in pony refrigerators the same day and shipped to Wenatchee, Wash., received July 18, held under ice till July 19 and then at room temperature till July 24, when notes were taken.
[3] The Lambert cherries were picked July 21, shipped in pony refrigerators the same day, received in Washington, D. C., July 30, when notes were taken.

TABLE V.—*Effect of spraying Napoleon cherries, 1918* [1]

Lot.	Orchard treatment.	Percentage of rot.					
		On fruit picked and packed in the middle of the day.			On fruit picked and packed in the cool of the morning.		
		Monilia.	Penicillium.	Rhizopus.	Monilia.	Penicillium.	Rhizopus.
A..	Bordeaux	1.5	9.4	1.0	.....	.....	.....
	Lime-sulphur	1.9	7.0	4.0	.....	.....	.....
	Lime-sulphur (last application omitted).	1.9	6.0	.3	.....	.....	.....
	Untreated	4.3	9.3	.6	.....	.....	.....
B..	Bordeaux	.6	2.9	26.9	0	0.8	8.7
	Bordeaux (last application omitted).	0	1.6	39.0	0	.2	52.3
	Lime-sulphur	.2	2.7	4.6	0	1.6	67.4
	Lime-sulphur (last application omitted).	.4	3.6	11.3	1.2	.6	42.9
	Untreated	6.5	1.2	41.0	1.2	.9	24.5
C..	Bordeaux	0	12.0	15.1	.2	.9	21.4
	Bordeaux (last application omitted).	.8	2.9	36.5	2.1	.8	31.5
	Lime-sulphur	0	.7	9.0	.2	6.2	60.4
	Lime-sulphur (last application omitted).	1.5	5.0	22.0	.4	3.2	19.0
	Untreated	10.0	1.9	33.7	2.8	5.8	64.8

[1] The cherries were picked June 26. Lot A was held 12 days at Salem, Oreg., in an open warehouse. Lot B was shipped in pony refrigerators to Wenatchee, Wash., held under ice till July 2, and without ice one day, notes being taken July 3. Lot C was shipped in pony refrigerators to Washington, D. C., arriving July 3, and held warm till July 5, when notes were taken.

TABLE VI.—*Effect of spraying Napoleon cherries, 1919* [1]

Plot No.	Orchard treatment.	Percentage of rot.							
		July 3, after 6 days in transit.		July 15, after storage at 15° C. (59° F.) for 12 days.			July 15, after storage at 5° C. (41° F.) for 12 days.		
		Monilia.	Penicillium.	Monilia.	Penicillium.	Rhizopus.	Monilia.	Penicillium.	Rhizopus.
1	Bordeaux	1.1	1.0	11.5	3.5	0	10.2	7.5	0
2	Lime-sulphur	1.0	1.2	13.8	4.5	0	12.3	4.2	0
3	Sulphur dust	14.7	22.8	9.3	37.0	35.2	19.4	26.5	0
4	Untreated	22.4	1.5	57.0	15.2	0	28.0	.7	0

[1] The cherries were picked from plots 1 and 2 on June 25. A rain followed on June 26, and the cherries from plots 3 and 4 were picked on June 27. The rain probably resulted in there being relatively less protective material left on the dusted than on the sprayed fruit. The picked fruit from plots 1 and 2 was not placed under ice till June 27, and this delay in cooling may have partly or entirely offset any harmful effects from the rains received by plots 3 and 4. Two 10-pound boxes from each plot were shipped in a pony refrigerator to Washington, D. C., were received warm July 2, were held overnight at a temperature of approximately 7° C. (44.6° F.), and notes were taken July 3. The sound fruit was saved, and half of the cherries from each plot were stored at a constant temperature of 5° C. (41° F.) and half at a constant temperature of 15° C. (59° F.). On July 15 notes were taken on the amount of rot that had developed in storage.

A discussion of the results from the cherry experiments is given on pages 474–477.

SPRAYED AND UNSPRAYED ITALIAN AND AGEN PRUNES IN TRANSIT AND IN STORAGE

The prune is best known as a dried product, but a considerable part of the western crop, especially from the irrigated districts, is shipped to the eastern markets as "green" or fresh prunes. The question of the development of rots is a very important one in such shipments, and it is also an important consideration when delays occur at the drying plants.

The spraying experiments were made in the orchards of A. W. Moody, Felida, Wash., and L. T. Reynolds, Salem, Oreg. Both Italian and Agen (Petite or French) prunes were included in the tests. The spray materials were similar to those described for the cherries. In 1915, 1918, and 1919 a 4–4–50 Bordeaux was used, and in 1916 and 1917 a 2–4–50 Bordeaux. In 1916 to 1919, inclusive, a 50–35–15 sulphur dust [1] was used in the earlier applications and a 50–50–0 in the last. In 1919 a second sulphur dust plot was given an 85–0–15 mixture in the earlier application and an 85–15–0 mixture in the last, and two different brands of Bordeaux dust were tested.

In 1915 sprayings were made March 24, April 8, May 1, June 21, and August 6 in the first orchard, and May 29, June 21, and August 6 in the second orchard; in 1916, April 8 to 12, April 25 to 27, May 30 and August 30 at Felida, Wash., and April 1, April 21, and June 16 at Salem, Oreg., in 1917, April 28, May 18, June 15, and September 12; in 1918, April 11, April 29, May 27, and August 20; and in 1919, April 8, April 25, May 21, and August 25. The earlier applications (before May 10) were for the control of blossom infection and probably had little effect upon the occurrence of rot on the ripe fruit.

TABLE VII.—*Effect of spraying Italian prunes, Felida, Wash., 1915* [1]

	Orchard treatment.	Percentage of Monilia rot at harvest.	Percentage of rot Sept. 21, after shipment and storage.			Percentage sound Sept. 21.
			Monilia.	Penicillium.	Rhizopus.	
First orchard.....	Bordeaux.....	0	2.7	27.7	33.5	36.1
	Self-boiled lime-sulphur.	0.9	7.0	36.4	31.5	25.1
	Commercial lime-sulphur.	.7	9.3	44.2	21.5	25.0
	Untreated.....	3.4	30.3	29.8	28.5	11.4
Second orchard...	Bordeaux.....	4.2	35.7	22.7	28.8	12.8
	Self-boiled lime-sulphur.	3.3	27.8	25.4	38.9	7.9
	Commercial lime-sulphur.	4.8	20.6	32.6	17.5	29.3
	Untreated.....	5.4	56.0	14.1	28.6	1.3

[1] The trees in the first orchard were 24 years old, and those in the second 15. The prunes were harvested Sept. 7 to 10, shipped to Wenatchee, Wash., by ordinary express, and held without refrigeration till Sept. 21.

[1] Fifty pounds sulphur dust, 35 pounds of lime, and 15 pounds arsenate of lead.

Although brown rot usually caused heavy losses in the neighboring orchards, sometimes destroying more than 75 per cent of the crop, it was never serious even on the control plots in the orchards in which the experiments were made. Notes were taken on the amount of rot at picking time and also on the amount developed in shipment and in storage. The shipping tests were carried out as described for the cherries. The prunes used in the experiments were carefully picked from the tree several days before the drying season began. They were too green for drying, yet riper than the average "green" prune shipments.

TABLE VIII.—*Effect of spraying Italian prunes, Felida, Wash., 1916*[1]

Orchard treatment.	Percentage of Monilia-rot at harvest.	Percentage of rot Sept. 19, after shipment.			Percentage of rot Sept. 23, after shipment and warm storage.		
		Monilia.	Penicillium.	Rhizopus.	Monilia.	Penicillium.	Rhizopus.
Bordeaux	1.3	2.7	0.2	0.3	8.0	12.1	12.8
Self-boiled lime-sulphur	2.4	.3	.1	.2	3.5	8.2	14.4
As above, but last application omitted	3.8	1.9	.8	1.1	19.4	1.1	2.9
Commercial lime-sulphur	2.2	0	0	0	6.5	0	8.9
Sulphur dust	1.6	.6	.6	1.5	2.8	8.4	11.4
Sulphur dust (last application omitted)	4.7	2.7	0	2.8	5.4	7.1	11.0
Untreated	8.0	0	0	0	32.3	7.7	0

[1] The prunes were harvested Sept. 12 and Sept. 23. Fruit from the first picking was shipped in pony refrigerators to Washington, D. C., received in good condition Sept. 19, and held at room temperature till Sept. 23.

TABLE IX.—*Effect of spraying Italian prunes, Salem, Oreg., 1916*[1]

Orchard treatment.	Percentage of rot after shipment and warm storage.		
	Monilia.	Penicilium.	Rhizopus.
Bordeaux	7.1	3.8	1.7
Self-boiled lime-sulphur	7.6	3.8	2.6
Commercial lime-sulphur	1.9	0	.8
Untreated	12.9	0	0

[1] The prunes were practically free from rot in the orchard, were harvested Sept. 6, shipped by express without refrigeration to Wenatchee, Wash., and held at room temperature till Sept. 16, when notes were taken.

TABLE X.—*Effect of spraying Italian prunes, Felida, Wash., 1917* [1]

Orchard treatment.	Percentage of rot.							
	Monilia at picking time.			After shipment to Wenatchee, Wash.			After shipment to Washington, D. C.	
	First picking.	Second picking.	Total.	Monilia.	Penicillium.	Rhizopus.	Monilia.	Penicillium.
Bordeaux	3.1	0.4	1.6	2.3	15.6	0	10.5	82.9
Self-boiled lime-sulphur	1.5	.3	.6	1.5	10.8	0	.....	.....
As above but last omitted	4.0	.7	1.5	1.8	48.1	0	.....	.....
Lime-sulphur 1–50	4.6	.4	2.0	.3	31.7	0	12.7	84.8
Sulphur dust	6.9	.8	3.8	2.8	36.2	0	.....	.....
Untreated	14.5	2.5	6.5	18.2	15.6	0	26.4	62.6

[1] The prunes were harvested Sept. 22, to 26 and Oct. 2 to 5. The shipment to Washington, D. C., was made in a pony refrigerator, started Sept. 25, received Oct. 11 with no ice and in such bad condition that several lots were discarded. The shipment to Wenatchee, Wash., was by express without refrigeration, started Sept. 26, received Sept. 28 and allowed to stand in a warm room till Sept. 30, when notes were taken.

TABLE XI.—*Effect of spraying Italian prunes, Felida, Wash., 1918* [1]

Orchard treatment.	Percentage of rot.						
	Monilia at picking time.	After shipment to Wenatchee, Wash., and 8 days' storage at 15° C.			After shipment to Washington, D. C., under ice and 2 days' delay at 25° to 30° C.		
		Monilia.	Penicillium.	Rhizopus.	Monilia.	Penicillium.	Rhizopus.
Bordeaux	0.3	1.3	1.1	18.8	0	0.4	31.9
Self-boiled lime-sulphur	.2	0	1.6	10.9	0	0	37.6
As above but last omitted	.2	.6	1.1	3.6	1.7	0	9.2
Commercial lime-sulphur	.5	0	.5	10.9	0	.4	34.3
As above but last omitted	.6	.3	.5	.3	0	.8	15.5
Sulphur dust	.1	.4	1.2	3.4	0	0	39.3
Untreated	.3	1.5	1.2	10.1	0	1.5	24.3

[1] The prunes were harvested Sept. 6 and 11. The shipment to Washington, D. C., was made in a pony refrigerator, started Sept. 6, received in good condition Sept. 14, and notes taken Sept. 16. The shipment to Wenatchee, Wash., was without refrigeration, started Sept. 11, received Sept. 12, and held in cellar storage till Sept. 20, when notes were taken.

TABLE XII.—*Effect of spraying Italian and Agen (Petite or French) prunes, Salem, Oreg., 1919* [1]

Variety.	Orchard treatment.	Percentage of rot.									
		Monilia at picking time.	After shipment to Wenatchee, Wash., without ice and 5 days' storage without ice, 18° C. (64.4° F.).			After shipment to Wenatchee, Wash., under ice and 5 days' storage under ice.			Total rot in the refrigerator shipment after the 5 days' cool storage had been followed by 2 days' warm storage.		
			Monilia.	Penicillium.	Rhizopus.	Monilia.	Penicillium.	Rhizopus.	Monilia.	Penicillium.	Rhizopus.
Italian	Bordeaux	1.6	29.9	.....	3.2	4.6	0	0	9.6	0	0
	Self-boiled lime-sulphur	[2] 1.1	.....	.....	.....	.....	.....	.....	.....	.....	.....
	As above but last omitted	[2] 2.5	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Commercial lime-sulphur	.6	12.5	2.1	.9	.7	0	0	3.9	0.4	0
	Untreated	8.3	71.8	1.3	1.3	17.5	0.5	0	36.1	.6	0
Agen	Self-boiled lime-sulphur	.1	.....	.....	.....	.6	0	0	11.0	1.3	1.1
	As above but last omitted	.2	.....	.....	.....	13.9	0	0	38.5	1.9	0
	Sulphur dust 50–35–15	.2	.....	.....	.....	.5	0	0	10.4	1.2	.2
	Sulphur-dust 85–0–15	.2	.....	.....	.....	.2	0	.02	7.6	1.1	.8
	Bordeaux dust A	.9	.....	.....	.....	2.8	0	1.3	20.2	.8	1.6
	Bordeaux dust B	8.7	.....	.....	.....	1.4	0	0	34.6	.2	0
	Untreated	1.8	.....	.....	.....	7.0	0	0	50.4	.2	0

[1] The prunes were harvested Sept. 15, shipped to Wenatchee, Wash., Sept. 16, received Sept. 18, and notes taken Sept. 23.
[2] No shipment.

The contrast in the amount of brown rot (Monilia) on the fruit from the different plots after shipment and storage is shown graphically in figure 1.

A study of the figure shows that the unsprayed fruit developed six to nine times as much brown rot under transportation and market

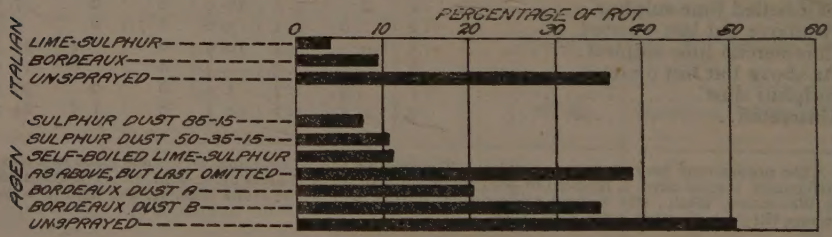


FIG. 1.—Brown rot on Italian and Agen prunes after shipment and storage. 1919.

conditions as the fruit from the plots receiving the best orchard treatment. The sulphur dust was as efficient as the sprays, but the Bordeaux dust was far less efficient.

The results show that orchard spraying may have great value on the market even when the amount of disease in the orchard has been negligible.

DISCUSSION OF RESULTS

In order to obtain the composite results from the various prune and cherry experiments the data from the different spraying and shipping tests have been brought together and averaged. The results are shown in figures 2 to 6, inclusive.

Figure 2 shows the comparative efficacy of spraying and dusting as determined by the average of the four years' results on prunes. Little contrast is shown between the two methods of treatment, both sulphur dust and self-boiled lime-sulphur having reduced the amount of brown rot at picking time from 4 per cent to approximately 1 per cent and

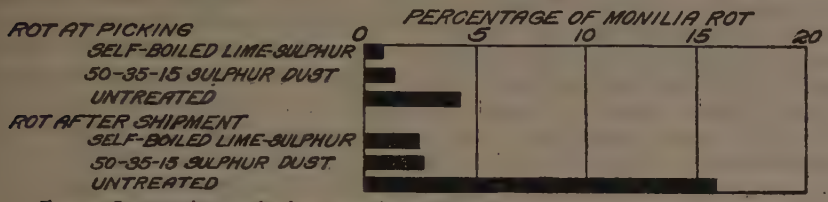


FIG. 2.—Comparative results from spraying and dusting in a four years' test on prunes.

reduced the amount developed in shipments from 16 per cent to 2.5 per cent.

It was pointed out earlier in the paper that the different spray applications were probably not of equal value in the control of brown rot on the fruit. The great importance of the last application in this connection is shown graphically in figures 3 and 4. A reference to these figures

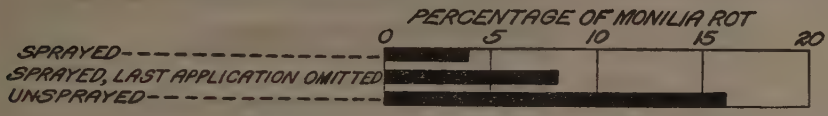


FIG. 3.—Brown-rot control of cherries as influenced by a late spray application (about three weeks before picking time). The average results obtained from 15 different shipping tests.

shows that with the prunes approximately one-half and with the cherries approximately one-third the brown-rot control was due to this late spraying.

The comparative results obtained with the different rots in the various shipping experiments are shown in figures 5 and 6. The term sprayed

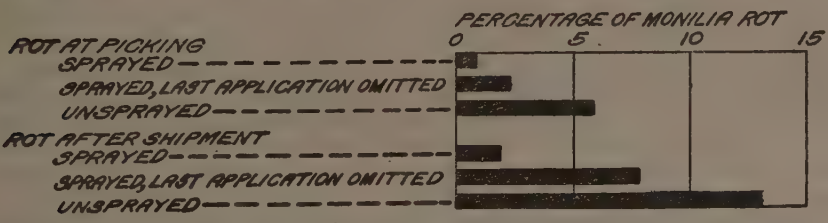


FIG. 4.—Brown rot control of prunes as influenced by a late application of spray or dust (three to five weeks before picking time). The average results obtained from 7 orchard experiments and 11 shipping tests.

as used in these two figures includes both dusting and spraying. As has already been pointed out, there was no year in which there was a serious epidemic of rot in the orchards under investigation. The amount of rot on the untreated cherries at picking time never ran as high as 1 per cent. The average amount of brown rot on the sprayed prunes at

picking time, as shown in figure 6, was 1.6 per cent and the average amount on the untreated prunes was 4.6 per cent. The orchard loss from rot with either the prunes or the cherries would be considered of very minor importance in practical operations, scarcely justifying the expense of spraying; yet even under these conditions the orchard spraying has shown decided beneficial effects in the carrying quality of the fruit in transportation and storage. The good effects, however, have been largely if not entirely confined to the control of Monilia rot. With both the prunes and cherries the unsprayed fruit has developed approximately four times as much of Monilia rot as the sprayed fruit, but has shown practically no greater susceptibility to Penicillium and Rhizopus rots. These contrasting results are in harmony with the nature of the different fungi. Monilia is a parasitic fungus and able to penetrate the sound skin of both ripe and green fruit; Penicillium and Rhizopus are saprophytic fungi, able to attack only the harvested fruit and dependent upon bruises and skin cracks for first points of entrance. The Monilia spores come primarily from the orchard, but Penicillium and Rhizopus have an almost universal distribution.

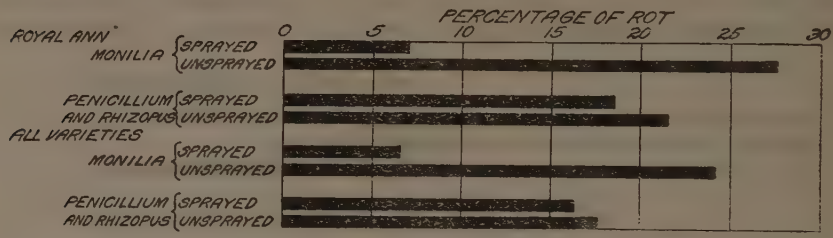


FIG. 5.—A comparison of the average development of rot on sprayed and unsprayed cherries in 18 different shipping and storage experiments.

Under such circumstances it would be expected that orchard spraying would furnish at least partial protection against brown rot in transportation and storage, since it would both decrease the supply of spores and furnish a more or less complete protecting film on the fruit. On the other hand, orchard spraying could not be expected to have any appreciable effect upon the spore supply of fungi like Penicillium and Rhizopus that are of general occurrence, and a film of spray on the skin could offer little protection against fungi that enter through breaks in the skin.

While these contrasts in the different fungi are of importance in connection with the present studies, it should not be inferred from the foregoing statements that skin punctures have no effect upon the occurrence of Monilia rot, for it is well known that any abuse to the fruit is decidedly favorable to the development of the disease; [1] nor should it be inferred that Rhizopus and Penicillium are entirely unable to penetrate the sound skin, for when these fungi are once well established in a crate they may spread out from a center of infection without much regard to the soundness of the adjacent fruit. This is particularly true of Rhizopus, and especially where it is favored by a high temperature. Under such a condition it often spreads through a package of stone fruit in a most rapid and indiscriminate manner.

[1] RAMSEY, H. J. THE HANDLING AND SHIPPING OF FRESH CHERRIES FROM THE WILLAMETTE VALLEY U. S. Dept. Agr. Bul. 331, 28 p., 11 fig., 1916.

With all the rots temperature has been an extremely important factor. In the 1919 experiments (Table VI) part of the fruit was stored at 15° C. and part at 5°, with striking contrasts in the results. Rhizopus was entirely eliminated at the lower temperature, and Penicillium and Monilia were greatly reduced. Short shipments without refrigeration have resulted in heavy losses, while fresh fruit, both sprayed and unsprayed, has been shipped across the continent in pony refrigerators under ice with no decay upon arrival. Fruit that was free from rot after seven days in the refrigerators became badly decayed after standing one or two days in a warm room, the unsprayed fruit always developing the most rot but the sprayed fruit never remaining free from it. Refrigeration is always valuable; but it is evident that its importance increases with any decrease in orchard or packing-house care.

It is evident that there is a widely distributed responsibility for the occurrence of stone fruit rots in transit and in storage. Orchard spraying may be one of the important factors in the control of Monilia rot on the

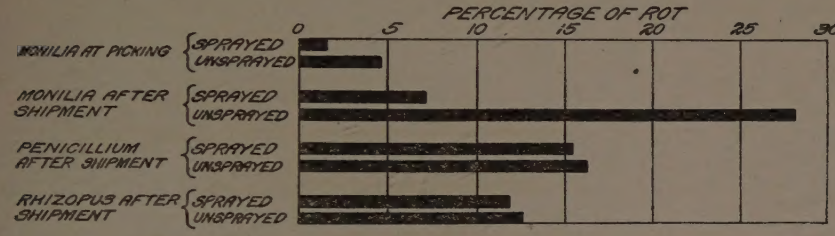


FIG. 6.—A comparison of the average development of rot on sprayed and unsprayed Italian prunes in 11 different shipping and storage experiments.

harvested fruit, but as a protection against Penicillium and Rhizopus rots it has little or no value.

SUMMARY

(1) Orchard spraying has reduced the amount of Monilia or brown rot developed on sweet cherries in transportation and storage experiments from 24.3 to 6.4 per cent. All the cherries were from orchards where there was less than 1 per cent of rot on either the sprayed or unsprayed fruit at picking time.

(2) In similar shipping and storage experiments with Italian prunes there has been an average of 28 per cent of brown rot on the untreated fruit and 7.1 per cent on the sprayed or dusted fruit. The amount of rot on the unsprayed fruit at picking time was 4.6 per cent and on the sprayed fruit 1.6 per cent.

(3) About half the brown rot control secured in the shipping tests with prunes and about one-third of that secured with cherries was due to the spray application made three or four weeks before picking time.

(4) There has been little contrast between the brown rot control secured with sulphur dust and that secured with the standard spray materials.

(5) Spraying and dusting have had little or no effect upon the development of Penicillium and Rhizopus rots in transit and storage, their occurrence apparently being much more influenced by the prevalence of bruises and skin punctures.

(6) The unsprayed fruit has shown a greater need of refrigeration than the sprayed, and the injured fruit a greater need than the sound.